Mental Organization and Age Level

BY

SUZANNE REICHARD, Ph.D.

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SECTION I. THE PROBLEM AND METHOD

1. Introduction

The purpose of this study is to investigate the effect of age upon mental organization. A hypothesis is presented that intelligence is relatively generalized in young children, but that as age increases there is a gradually increasing specialization of mental abilities. If this hypothesis is true, tests designed to measure certain special abilities should, when administered to children of different age levels, show a decrease in their intercorrelations with increase in age. At the same time there should be an increase in the correlations between tests of the same ability.

There have appeared, so far, two main theories in regard to mental organization. The first of these was Spearman's unitary factor theory, which involved a "common essential element in the intelligences" (13, 19). According to Spearman (20), performance on any test involved a certain amount of the general intelligence factor, which he called *g*, and, in addition, a second factor, *s*, which was specific to each test. *g* was defined as mental energy and was assumed to show its highest saturation in tests of abstract reasoning ability, or what Spearman called "eduction of relations." The main opponent of this theory was Thorndike (21), who in 1913 put forward his theory of the "thoroughgoing specialization of the mind," which predicated the existence of innumerable specific abilities. The extreme specificity of this view was later modified to imply the existence of a relatively small number of group factors, which cut across subject matter lines and were responsible for performance on varying types of tests (23). Spearman (20) also later broadened his theory to include a number of group factors in addition to *g*, but Kelley (15) was one of the first psychologists to define some of these factors. He found evidence of the existence of verbal, number, memory, spatial and speed factors, plus Alpha, a maturity and heterogeneity factor. Anastasi (1), Dubois (6), and Schiller (16) have more recently produced evidence of the existence of these group factors. However, the most active proponent of the group factor theory of intelligence at the present time is Thurstone (25), who through the application of his improved technique of factor analysis, not only verified the previous findings in regard to the above-named factors, but identified several new ones. In his earlier writings he denied that there was any evidence for a general factor in intelligence, and stated that all the phenomena could be adequately explained in terms of group factors. Although continuing to emphasize group factors in his later work, he accepted the possibility of a general factor (27).

As Dael Wolfle (28) has pointed out, the different methods of factor analysis employed by Spearman and Thurstone were devised to test their respective theories in regard to mental organization. Spearman's method of tetrad differences was intended to bring out a general factor in intelligence, while Thurstone's centroid method (24) was aimed at discovering group factors. However, Wolfle demonstrated that the two methods could be used interchangeably, and that there was a very high degree of correspondence between the two sets of results. Actually, both methods produce a large first factor, the interpretation of which varies. Spearman has called it general intelligence, whereas Thurstone states that it is meaningless until rotated, when it will be found to be identified with those tests in which it appears most strongly. Furthermore, the correlation between the various group factors is not zero, as it should be if they are strictly independent, but is of a low positive order, thereby indicating the presence of some common factor in addition to group factors. Garrett (11) sought to explain this correlation in terms of similarity in background, training, and even modes of thought. Kelley (15), on the other hand, thought it might be due to the rates of maturation of different abilities. If there was a basic rate of maturation for each individual, the different factors should be correlated throughout childhood, even though they may be uncorrelated in adults. Thurstone (25) also anticipated the possibility of changes in the intercorrelations at different stages of development, which he originally tried to explain without benefit of a general factor. He stated that if it should be established that the intercorrelations of psychological tests tend to decrease with age, the effect can be simply explained by assuming that, if the mental abilities of a young child are not clearly differentiated, he will use a wider spread of abilities in solving a problem than later, when he can restrict his efforts to those abilities that are most appropriate for the problem. However, by factor analysis of the correlations between his primary abilities, he later extracted a second order factor, which he regarded as being identical with *g* (27). Like Spearman, he found the highest saturation of this factor in tests of inductive reasoning.

Thus arose the question as to whether mental organization might not change with age; whether a general factor might not be more prominent at certain stages of development, while group factors predominated at others. Several studies on this topic have been published by Garrett and his associates, who have adduced a body of evidence in support of the hypothesis advanced at the beginning of this paper. For example, Garrett (10) obtained an *r* of only .21 between arithmetic and vocabulary in a group of 338 college freshmen women; whereas Thorndike (23) had previously reported an *r* of .52 between tests of arithmetic and vocabulary in a group of 126 fifth-grade pupils. At the preschool level Bryan (5) found that various tests of memory were as closely related to tests of verbal ability and general intelligence as to each other. On the other hand, Anastasi (1) found that at the college level immediate memory for various types of material broke away sharply from both verbal and number ability. Thurstone (27) found that the intercorrelations of the group factors were higher for eighth-grade children than for adults.

The first study directed specifically at the question of change in mental organization was that of Garrett, Bryan and Perl (12), who tested 9-, 12-, and 15-year-old children with six memory and four non-memory tests. They found that with increases in age the abilities measured tended to become more and more specific, as shown by the decrease in the average intercorrelations of groups of tests and by multiple factor analysis of the correlations.

The next study was that of Asch (3), who proposed a somewhat different hypothesis from ours; namely that the ''intercorrelations are higher at childhood than during infancy, and lower at adolescence and maturity than during childhood.'' He re-tested a group of 12-year-old children, previously tested by Schiller (16) at the age of 9 years. The same tests were used for both studies, but more difficult items were added for the older group. There were four tests of verbal ability and three tests of number ability, as well as portions of Army Beta. The results showed a consistent drop in both the intergroup and the intragroup *r*'s with increase in age, the only exception being the average intercorrelation of the verbal tests and Army Beta which, in the case of the girls, showed a rise. Factor analysis revealed a large first factor, interpreted as ''general ability,'' which, however, accounted for a smaller percentage of the test variance at the 12-year level than at the 9-year level. Asch's study provided confirmation of the second part of his hypothesis but, since he tested only two age levels, it failed to throw any light on the first part. Nevertheless, he drew the following conclusions: (1) ''relations between performance are lowest at the pre-linguistic level'';

(2) "there is an increase in organization with the development of symbolic speech"; (3) "at a period of time preceding the age of 12, there occurs a decrease in the intercorrelations between certain intellectual performances." His first two conclusions were based on evidence from outside sources; namely, a study by Furfey, Bonham, and Sargent (8), who failed to find any general factor in the ratings on 17 tests of reflex alertness administered to infants during the first few days of life. The average *r* for all the tests was .044. However, the *r*'s were found to be higher for reflexes involving only one part of the body. The investigators concluded that there was no mental integration in the newborn. Later studies by Furfey and Muehlenbein (9) and by Bayley (4) failed to show any relationship between tests given a few months apart during infancy, and between the I.Q.'s on these tests and Stanford-Binet I.Q.'s obtained at the age of four years or more.

In 1938 Garrett (11) published a paper summarizing the findings in regard to the relationship between mental organization and age level up to that time. He also subjected a number of the earlier studies to factor analysis by Thurstone's centroid method (24), in an endeavor to clarify further the relationships involved. As a result of this treatment, Schiller's tests of 9-year-old boys (16) showed an *r* of .825 between the verbal and number factors; whereas a study of male college students by Schneck (17) revealed an *r* of only .225 between these two factors. A similar figure resulted from the factor analysis of Anastasi's second study of memory (2), in which the *r* between the verbal and number factors was .242 for women college students. The *r* of .058 between the verbal and memory factors in this study was compared with the *r* of .446 obtained from Bryan's study of 5- to 6-year-old boys (5), which again pointed to a drop in the correlation between abilities with increase in age. Garrett concluded that the comparison of adult correlations with those of children indicates a lack of differentiation between abilities in children as contrasted with adults.

The aim of the present study was to investigate further the effect of age upon mental organization, utilizing an experimental setup in which all the variables other than age were carefully controlled. This was felt to be desirable, since up to the present time there exist only two studies on mental organization, namely those of Garrett, Bryan and Perl (12), and Asch (3), which have attempted to insure homogeneity of test content and of the populations tested at the different age levels. Our study was modelled to some extent on that of Garrett, Bryan and Perl, but it aimed to extend the scope of the latter for, inasmuch as they used only one test of each ability other than memory, no adequate comparison of intragroup with intergroup relationships was possible. In this study it was planned to develop a battery of three tests of each of four group factors, verbal, number, memory and spatial ability, to be administered to 9-, 12-, and 15-year-old children; however, this ideal of three tests for each group factor had to be abandoned in some instances for reasons which will be discussed later.

2. SUBJECTS

Our subjects were 9-, 12-, and 15-year-old children in the Manhasset, Garden City and Bronxville public school systems. The work was begun in the Manhasset public schools, but when it was found that this school system alone could not supply a sufficient number of children for the purposes of the study, additional groups were tested in the Garden City and Bronxville public school systems. These schools were selected because they were relatively homogeneous in regard to the populations which they served, as they were all situated in neighborhoods of a high socio-economic level with a population consisting largely of business and professional people. In this way an attempt was made to minimize any effects that might result from gross differences in socio-economic level of the subjects. All the children were American-born and drawn from homes in which English was the principal language spoken, in order to eliminate the effects of language handicap. All children aged 9 to 9–11, 12 to 12–11, and 15 to 15–11 at the time of testing were tested in the public school systems of Manhasset (Manhasset and Munsey Park Schools), and Garden City (Garden City and Stratford Schools). The 9-year-old children ranged from grades II to V, the 12-year-olds from grades V to VIII, and the 15-year-olds from grades VIII to XI. At every age level the tests of many of the subjects could not be used because of failure to complete the battery, or because a test was spoiled through failure to understand the directions; but this loss was greatest at the 9-year level and necessitated our drawing upon an additional group of 9-year-old children in the Bronxville public school system. We tested a total of 729 children, but after we had discarded all subjects whose records were incomplete in some respect, our final group consisted of 542 subjects, of which 280 were girls and 262 were boys. Table 1 shows the distribution of the children throughout the various school systems.

TABLE 1

DISTRIBUTION OF SUBJECTS

9 years

Number of boys: 85

Grade	3	4	5
Manhasset	2	14	......
Munsey Park	2	15	......
Stratford	4	28	1
Bronxville	6	13	......
Total	14	70	1

Number of girls: 71

Grade	3	4	5
Manhasset	1	12	......
Munsey Park	......	8	1
Stratford	9	22	2
Bronxville	3	13	......
Total	13	55	3

12 years

Number of boys: 89

Grade	5	6	7	8
Manhasset	......	4	20	2
Garden City	2	9	51	1
Total	2	13	71	3

Number of girls: 99

Grade	5	6	7	8
Manhasset	......	8	26	4
Garden City	1	12	48	......
Total	1	20	74	4

15 years

Number of boys: 88

Grade	8	9	10	11
Manhasset	6	6	23	3
Garden City	......	7	39	4
Total	6	13	62	7

Number of girls: 110

Grade	8	9	10	11
Manhasset	1	10	26	5
Garden City	......	8	51	9
Total	1	18	77	14

3. THE TESTS

As already mentioned in the discussion, the intention had been to construct a battery of twelve tests consisting of three tests each for each of four factors, verbal, number, memory and spatial ability; however, the final battery consisted of only eight tests: three tests of verbal ability, two tests of number ability, two tests of memory ability and one test of spatial ability. There were several reasons for this reduction in number. In the case of the tests of number ability it was considered desirable to keep them as free as possible of any verbal factor. For this reason arithmetical problems were not included in the battery. Furthermore, in order to reduce any misunderstanding of instructions to a minimum, each type of computation was given separately; *i.e.,* all the addition items were given first, then all the multiplication items, etc. A factor which rendered difficult the selection of tests not only for number ability, but for the other group factors as well, was the necessity of selecting tests with a wide range of difficulty, such that they contained items easy enough for 9-year-old children and difficult enough for the 15-year-old children. Hence, such a test as equation relations could not be employed because it would be too difficult for the younger group. For these reasons it was found impossible to discover more than two tests of number ability suitable for inclusion in our battery. We had originally three tests of memory ability, but one of these, Geometrical Forms,[1] had to be discarded because of low reliability. In the beginning there were also three tests of spatial ability, but the results from two of these, Thurstone's Flags,[2] and Designs,[3] had to be discarded; the former because too many of the 9-year-old children failed to understand the directions (although with better directions they might have been able to do the test), and the latter because the results were very erratic and in no way approximated a normal distribution.

The original battery of twelve tests was first tried out on several groups of dull 9-year-old children and several groups of bright 15- and 16-year-old children in a number of different orphan homes in New York City in order to determine suitable time limits and directions. The final battery consisted of the following eight tests:

A. *Tests of Verbal Ability*

1. *Vocabulary.* The vocabulary test was the same as that used by Garrett, Bryan and Perl (12) and consisted of mimeographed sheets containing 60 items selected from the Thorndike CAVD vocabulary test, five items being drawn from every level from F to Q inclusive. Each item consisted of a word to be defined followed by a group of five other words. The subjects were instructed to draw a line under the one word in the group which meant the same or nearly the same as the test word. *Time:* 8 minutes. *Score:* Number correct. *Reliability:* Odd versus even items.

2. *Analogies.* This test was devised in the Columbia University psychological laboratories. It consisted of 60 pairs of words related in some way, *e.g.,* opposites or synonyms, then a third word followed by a group of four words. The subjects were required to draw a line under the one word in the group which was related to the third word in the same way that the second word was related to the first. *Time:* 9 minutes. *Score:* Number right. *Reliability:* Odd versus even items.

3. *Sentence Completion.* This was the Completion Exercise Alpha devised by Kelley and Trabue. The test consists of 40 sen-

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[1] This test was devised by Jones and is described in detail by Woolley (29).

[2] This test was devised by L. L. Thurstone (25) and consists of American flags drawn in a number of different positions of which the subject is required to tell of each flag whether it is the same or the reverse of an original flag.

[3] A test designed by the author as a kind of paper and pencil Kohs Block Designs.

tences with one or more empty spaces in each, which are to be filled in by the subject in order to make the whole sentence sound sensible and right. *Time:* 20 minutes for 12- and 15-year-old children, 15 minutes for 9-year-old children. *Score:* 2 points for each correct sentence, 1 point for sentences with minor errors, 0 for incorrect sentences. *Reliability:* Odd versus even items.

B. *Tests of Number Ability*

4. *Number Series.* This test was made up by combining two tests produced in the Columbia University psychological laboratories. It consisted of 50 series of numbers with six numbers in each, and was to be completed by filling in the next two numbers of the series in each case. *Time:* 15 minutes for 12- and 15-year-old children, 12 minutes for 9-year-old children. *Score:* Number right. *Reliability:* Odd versus even items.

5. *Arithmetic Computation.* This consisted of the addition, multiplication and division sections of the Buswell-John Diagnostic Chart for Fundamental Processes in Arithmetic. The sections were administered separately. The addition section consisted of 46 items, multiplication of 44 items, and division of 42 items. *Time:* Addition 4 minutes; multiplication 6 minutes; division 10 minutes. *Score:* The total of the number right in each of the three sections; *i.e.*, the sum of the three sub-scores. *Reliability:* Odd versus even items.

C. *Tests of Memory*

6. *Word-Word.* This test was devised by the author and consisted of paired four-letter words gummed on white cards, 6 × 20 inches long. Willson's black gummed letters, 4 inches high, were used for making the words. A sample set of three cards was given first, and then two sets of ten cards each. The cards were first shown to the subjects with both words exposed, then the order was changed and the cards were shown again with only the first word of each pair exposed. The subjects wrote down the missing words as the cards were shown the second time. *Time:* 5 seconds exposure per card. *Score:* Number right. *Reliability:* First set versus second set.

7. *Digit Span.* The test consisted of series of digits, three to thirteen digits in length, with two series of each length. 4-inch black digits were gummed on white cards. *Time:* 1 second exposure per digit for exposure, and 1 second per digit for writing. *Score:* The sum of the highest number of digits in the even series plus the

highest number of digits in the odd series perfectly reproduced. *Reliability:* Odd versus even items.

D. *Tests of Spatial Ability*

8. *Paper Form Board.* This test consisted of the Likert-Quasha Revision of the Minnesota Paper Form Board Test. The test contains 64 items, each item consisting of a sample figure with two or more separate parts, and five other completed figures from among which the subject has to select that one which is made up of the same parts as the sample. *Time:* 20 minutes. *Score:* Number correct. *Reliability:* Odd versus even items.

As indicated in the descriptions of the tests, all the material was presented visually. During five weeks in the spring of 1940 the author tested the children in the Manhasset public school system. The following spring Miss Helen Rome and the author tested the children in the Garden City and Bronxville public school systems. Miss Rome and the author worked together for the first three weeks, after which the former continued the testing alone. The tests were administered to the subjects in small groups of 15 to 20 children, in order to permit a fair amount of individual supervision. Exceptions to this were the arithmetic tests which were administered to large groups of as many as 60 children at one time. The examiners had the assistance of monitors when these large groups were tested. The administration of the tests required three to four lesson periods, since the length of the testing periods had to be varied somewhat in order to conform to the length of the lesson periods in the different schools. The longest testing period was 1 hour and 20 minutes (in the Manhasset high school), and the shortest was about 45 minutes. In the case of the younger children the sessions never lasted longer than 1 hour.

SECTION II. RELIABILITY OF TESTS, AGE AND SEX DIFFERENCES, FORM OF DISTRIBUTION OF SCORES

1. Reliability of Tests

The means, standard deviations, and reliability coefficients for all of the tests employed in this study are reported for the three age groups in Tables 2, 3, and 4. The reliabilities of all the tests were calculated by the odd versus even method, with the exception of the Word-Word Test in which case the scores on the first series versus the second series were used.

TABLE 2[1]

Means, Standard Deviations, and Reliability Coefficients for 85 Boys and 71 Girls, 9–10 Years of Age
The unit throughout is the test item

Tests	*Means*		*S.D.'s*		*Reliability*	
	Boys	*Girls*	*Boys*	*Girls*	*Boys*	*Girls*
1 Vocabulary	18.92	19.04	6.84	5.84	.90	.88
2 Analogies	17.98	19.65	9.16	9.16	.95	.92
3 Sentence Completion	21.81	24.03	10.13	8.57	.91	.86
4 Number Series	17.04	16.59	5.54	6.32	.83	.90
5 Computation	50.39	54.10	18.83	19.81	.97	.97
6 Word-Word	3.41	4.48	2.71	2.86	.59	.68
7 Digit Span	11.34	11.86	2.88	2.35	.82	.81
8 Paper Form Board	26.89	25.96	8.03	8.79	.83	.88

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[1] These computations were made by the Columbia University Statistical Bureau.

TABLE 3

Means, Standard Deviations, and Reliability Coefficients for 89 Boys and 99 Girls, 12–13 Years of Age

Tests	*Means*		*S.D.'s*		*Reliability*	
	Boys	*Girls*	*Boys*	*Girls*	*Boys*	*Girls*
1 Vocabulary	29.67	29.32	5.75	5.81	.85	.90
2 Analogies	38.25	38.58	9.66	9.84	.92	.91
3 Sentence Completion	38.24	39.52	8.15	9.69	.84	.89
4 Number Series	27.72	27.40	6.78	6.34	.91	.93
5 Computation	97.89	100.32	11.26	11.93	.95	.95
6 Word-Word	7.29	6.94	3.69	4.01	.76	.79
7 Digit Span	14.31	14.70	2.42	2.49	.79	.76
8 Paper Form Board	38.57	36.25	9.35	9.11	.90	.89

TABLE 4

Means, Standard Deviations, and Reliability Coefficients for 88 Boys and 110 Girls, 15–16 Years of Age

Tests	*Means*		*S.D.'s*		*Reliability*	
	Boys	*Girls*	*Boys*	*Girls*	*Boys*	*Girls*
1 Vocabulary	36.86	37.36	5.80	5.81	.79	.85
2 Analogies	45.72	46.11	6.29	5.32	.81	.80
3 Sentence Completion	44.88	47.30	8.66	8.61	.79	.78
4 Number Series	32.92	32.28	6.34	6.34	.90	.89
5 Computation	104.66	105.79	9.83	11.32	.91	.92
6 Word-Word	7.47	9.35	4.14	3.76	.76	.75
7 Digit Span	15.34	15.73	2.09	2.65	.67	.68
8 Paper Form Board	42.08	40.67	9.29	8.28	.91	.92

2. Sex Differences

If we take a D/SD_d of 2.5 or more to indicate a significant difference, we find that there are no true differences between girls and boys on any of the tests with the single exception of the Word-Word Test at the 15-year level, on which girls are reliably superior to boys (Table 5). However, although the differences are not significant, the girls show a consistent tendency to superiority on tests of verbal ability and memory at all age levels, whereas the boys show a consistent superiority on the test of spatial relationships. The tests of number ability show two opposing trends, in that boys are superior on Number Series, but girls are superior on Computation at all age levels.

TABLE 5

Sex Differences

Sex differences at age levels 9, 12, and 15. Differences are expressed in terms of the S.D.(diff.). Negative entries denote differences in favor of the girls; positive entries differences in favor of the boys.

$$\frac{\text{Diffs. in Means}}{\text{S.D.(diff.)}}$$

Tests	*9*	*12*	*15*
1 Vocabulary	− .12	.42	− .60
2 Analogies	−1.13	− .23	− .47
3 Sentence Completion	−1.48	− .98	−1.96
4 Number Series	.46	.33	.70
5 Computation	−1.19	−1.44	− .75
6 Word-Word	−2.38	.63	−3.30
7 Digit Span	−1.24	−1.07	−1.15
8 Paper Form Board	.69	1.72	1.11

3. Age Differences

As may be seen in Table 6, 12-year-old boys and girls are reliably superior to the 9-year-olds on all the tests. The 15-year-olds are reliably superior to the 12-year-olds on all the tests with the exception of the Word-Word Test, which failed to show a significant difference between 12- and 15-year-old boys. The gains on all tests are smaller between 12 and 15 years than between 9 and 12 years, indicating a leveling off in the age-progress curve in the older chil-

TABLE 6

Age Differences

All differences are expressed in terms of S.D. differences. Positive entries denote differences in favor of the older of the two groups compared; negative entries indicate differences in favor of the younger group.

$$\frac{\text{Diffs. in Means}}{\text{S.D. (diff.)}}$$

Tests	Boys		Girls	
	9 & 12	12 & 15	9 & 12	12 & 15
1 Vocabulary	11.20	8.28	11.34	9.99
2 Analogies	14.19	6.10	12.88	6.78
3 Sentence Completion	11.76	5.25	11.01	6.12
4 Number Series	11.40	5.27	10.99	5.56
5 Computation	20.07	4.27	17.52	3.39
6 Word-Word	7.93	.29	4.67	4.46
7 Digit Span	7.35	3.02	7.58	2.90
8 Paper Form Board	8.83	2.50	7.41	3.66

TABLE 7

Age Differences in Variability

All differences are expressed in terms of S.D. differences. Positive entries denote greater variability of the older of the two groups compared; negative entries indicate greater variability of the younger group.

$$\frac{\text{Diffs. in S.D.}}{\text{S.D. (diff.)}}$$

Tests	Boys		Girls	
	9 & 12	12 & 15	9 & 12	12 & 15
1 Vocabulary	−1.61	.82	− .06	0
2 Analogies	.50	−3.90	.65	−5.75
3 Sentence Completion	−2.00	.57	1.12	−1.20
4 Number Series	1.87	− .63	.04	0
5 Computation	−4.53	−1.28	−4.21	− .54
6 Word-Word	2.83	1.08	3.08	− .66
7 Digit Span	−1.61	−1.37	.53	.64
8 Paper Form Board	1.43	− .81	.33	− .97

dren. Tests of verbal ability show slightly larger gains for girls than for boys between 12 and 15 years, while boys show slightly larger gains on tests of number ability.

Since large differences in variability, whether resulting from the effects of selection or from other causes, would invalidate the comparison of correlation coefficients from one age level to another, the relationship of variability to age is presented in Table 7. It is apparent that there is no consistent tendency for variability to increase or decrease with age. In 16 comparisons of 9- and 12-year-olds the four significant differences are in two cases in favor of the older, and in two in favor of the younger group. There are only two significant differences between the 12- and 15-year-olds and both are in the direction of the younger group.

4. Form of Distribution of Scores

If the form of the distribution of scores were found to be normal for the 12-year-olds but skewed in either of the other groups, the higher correlations at 12 years might have resulted from a restriction in the range of scores in the other groups. Such a state of affairs could arise if the tests were too difficult for the youngest children, with a consequent piling up of scores at the lower end of the scale; or if they were too easy for the oldest children, resulting in an accumulation of scores at the upper end of the scale. Tables 8, 9, and 10 show the amount and significance of the skewness for each of the tests at the three age levels, calculated by Kelley's formula. Only three of the 48 distributions are significantly skewed, and all of these occur in the 12-year group. Thus, it is clear that the rise in the correlations at the 12-year level cannot be accounted for by differences in the form of the distributions.

TABLE 8

Skewness—9-Year-Old Groups

Tests	*Boys*		*Girls*	
	Sk	*Sk/S.D.sk*	*Sk*	*Sk/S.D.sk*
1 Vocabulary	−2.1	2.0	−1.0	1.1
2 Analogies	.4	.3	1.7	1.1
3 Sentence Completion	−1.8	1.1	− .3	.2
4 Number Series	−1.9	2.3	−1.6	1.5
5 Computation	−2.5	.9	−4.1	1.2
6 Word-Word	.7	1.6	.3	.7
7 Digit Span	0	0	.7	1.8
8 Paper Form Board	1.1	1.0	0	0

TABLE 9

SKEWNESS—12-YEAR-OLD GROUPS

Tests	*Boys*		*Girls*	
	Sk	*Sk/S.D.sk*	*Sk*	*Sk/S.D.sk*
1 Vocabulary	– .8	.9	– .5	.6
2 Analogies	–3.8	2.7	–4.1	2.9
3 Sentence Completion	–2.6	2.3	–2.4	1.7
4 Number Series	– .3	.4	–1.4	1.6
5 Computation	1.8	1.1	–4.2	2.8
6 Word-Word	1.2	2.3	1.3	2.3
7 Digit Span	0	0	– .7	2.0
8 Paper Form Board	–3.1	2.3	1.8	1.4

TABLE 10

SKEWNESS—15-YEAR-OLD GROUPS

Tests	*Boys*		*Girls*	
	Sk	*Sk/S.D.sk*	*Sk*	*Sk/S.D.sk*
1 Vocabulary	– .9	1.0	.6	.8
2 Analogies	– .9	1.0	–1.4	2.1
3 Sentence Completion	.2	.2	.1	.1
4 Number Series	– .5	.5	– .6	.8
5 Computation	–2.3	1.7	–2.7	2.0
6 Word-Word	.9	1.6	1.1	2.3
7 Digit Span	– .2	.7	.4	1.2
8 Paper Form Board	–1.7	1.2	–1.4	1.3

SECTION III. THE INTERRELATIONSHIPS OF TESTS OF FOUR DIFFERENT ABILITIES AT THREE DIFFERENT AGE LEVELS

1. Correlations of Eight Mental Tests at Ages 9, 12, and 15

Tables 11, 12, and 13 present the intercorrelations of all our tests, computed separately for boys and girls at each of the three age levels. Entries above the diagonal refer to boys, those below to girls. Table 14 summarizes these results showing the average *r*'s for both the intragroup and intergroup correlations as computed with the aid of R. A. Fisher's *z* function (7).

Examination of the average intergroup correlations in Table 14 reveals that the theoretically expected drop in the correlations occurs

TABLE 11[1]

Intercorrelations of Eight Tests—9-Year-Old Groups
(Boys above Diagonal, Girls below)

	1	*2*	*3*	*4*	*5*	*6*	*7*	*8*
1 Vocabulary		.547	.772	.357	.315	.385	.423	.248
2 Analogies	.695		.629	.336	.465	.369	.343	.377
3 Sentence Completion	.684	.652		.384	.462	.448	.413	.292
4 Number Series	.477	.684	.497		.294	.129	.071	.247
5 Computation	.464	.578	.412	.495		.201	.325	.214
6 Word-Word	.282	.358	.482	.301	.340		.131	.031
7 Digit Span	.361	.539	.482	.413	.386	.360		.344
8 Paper Form Board	.405	.489	.387	.486	.479	.413	.288	

TABLE 12

Intercorrelations of Eight Tests—12-Year-Old Groups
(Boys above Diagonal, Girls below)

	1	*2*	*3*	*4*	*5*	*6*	*7*	*8*
1 Vocabulary		.590	.627	.448	.446	.214	.512	.379
2 Analogies	.731		.648	.620	.485	.431	.326	.551
3 Sentence Completion	.725	.790		.494	.472	.315	.506	.416
4 Number Series	.496	.619	.604		.569	.308	.231	.492
5 Computation	.579	.596	.595	.671		.241	.410	.393
6 Word-Word	.273	.377	.400	.234	.195		.191	.273
7 Digit Span	.522	.584	.555	.502	.596	.101		.251
8 Paper Form Board	.391	.490	.419	.557	.374	.155	.461	

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[1] These computations were made by the Columbia University Statistical Bureau.

TABLE 13

INTERCORRELATIONS OF EIGHT TESTS—15-YEAR-OLD GROUPS
(Boys above Diagonal, Girls below)

	1	*2*	*3*	*4*	*5*	*6*	*7*	*8*
1 Vocabulary		.613	.660	.435	.346	.460	.390	.138
2 Analogies	.609		.640	.493	.341	.436	.444	.250
3 Sentence Completion	.603	.631		.473	.288	.417	.315	.196
4 Number Series	.446	.580	.593		.619	.315	.277	.413
5 Computation	.336	.417	.285	.490		.224	.358	.234
6 Word-Word	.156	.394	.390	.406	.248		.165	.185
7 Digit Span	.222	.375	.261	.302	.408	.146		.123
8 Paper Form Board	.265	.241	.200	.338	.261	.197	.169	

between the ages of 12 and 15 years in both boys and girls; but contrary to theory, there is no drop but actually a rise in correlation between the ages of 9 and 12 years. In the case of the girls the average r at 15 is lower than that at 9 years, but this is not the case with the boys. In other words, the pattern of mental growth, as shown by our results, reveals an increase in the relationship between tests of different abilities up to about 12 years of age, after which the relationship again decreases. Figure 1 shows that the rise is

TABLE 14[2]

AVERAGE INTERCORRELATIONS OF VARIOUS GROUPS OF TESTS

	Boys			*Girls*		
	9	*12*	*15*	*9*	*12*	*15*
Intragroup r's						
Verbal	.660	.622	.638	.677	.750	.615
Number	.294	.569	.619	.495	.671	.490
Memory	.131	.191	.165	.360	.101	.146
Total	.510	.541	.559	.591	.645	.513
Intergroup r's						
Verbal—Number	.388	.497	.399	.525	.583	.450
Verbal—Memory	.397	.390	.411	.416	.459	.302
Verbal—Spatial	.306	.452	.195	.428	.434	.236
Number—Memory	.183	.299	.294	.361	.396	.359
Number—Spatial	.231	.444	.326	.483	.471	.300
Memory—Spatial	.192	.262	.154	.352	.316	.183
Total	.316	.407	.333	.442	.469	.331
Combined Intragroup and Intergroup r's						
Total	.353	.432	.377	.468	.505	.366
Boys and girls combined	....	....	....	*.413*	*.469*	*.372*

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[2] Since the correlations for the girls run generally higher than for boys it is well to keep them separate. This was not the case in the studies of Schiller (16) and Garrett, Bryan and Perl (12).

steeper for boys than for girls, whereas the girls show a steeper decline than do the boys. Were data for the intervening age levels available, it is possible that the apex of the correlation curve for girls would be found to occur somewhat before 12 years, that for boys somewhat after the age of 12.[3] In other words, the upper limits in this function may be reached earlier in girls than in boys. Computation of average r's from r's corrected for attenuation (see Appendix 1) causes the boys' results to conform slightly more closely with the original theory, but fails to change the girls' results. Nor can these trends be explained on the basis of a restriction in the range of ability at the 9-year level since, as has already been shown, there is no significant difference in variability between the different age levels. It was also thought that the low correlation at the 9-year level might be due to variability in training in the basic skills of reading, writing and arithmetic, since about one sixth of the 9-year-old children were in the third grade, where the acquisition of these skills is considerably less advanced than in the fourth grade. The question no longer arises in the case of the older children, since the acquisition of the basic skills to the degree necessary for performance on our tests is complete by the time the twelfth year of age is reached. Such differences in training might conceivably have caused a considerable drop in the correlation between tests involving school learning, such as the verbal and number tests, and those which do not, such as the test of spatial relationships. In order to check on

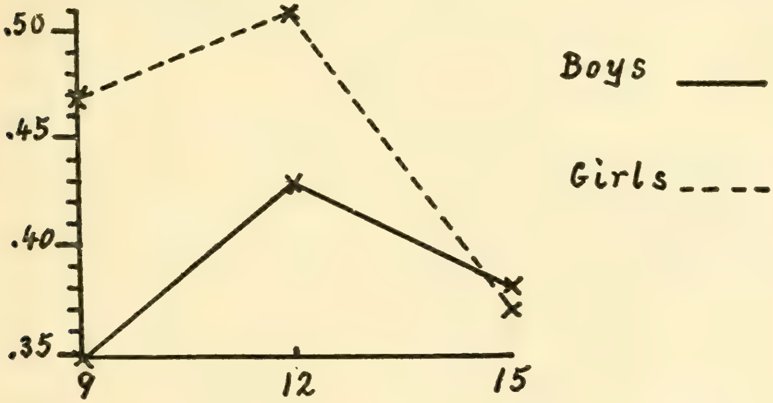

FIG. 1. Growth curves of the average correlations for boys and girls.

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[3] While there is no evidence that boys and girls differ in general intelligence level, they are known to differ in certain abilities; hence it is conceivable that they may also show some age differences in mental organization.

this point a few of the r's for boys 9 and 12 years old were re-computed for boys in the fourth and seventh grades only (see Appendix 2), but the attempt was discontinued as soon as it became clear that this procedure did not alter the general trend of the results.

2. FACTOR ANALYSIS

In an attempt to investigate still further the influence of a general intelligence factor on our test results, each table of correlations was analyzed by Thurstone's Multiple Factor Method (24). The analysis was not carried beyond the determination of the first factor loading. Inspection of the results in Table 15 shows precisely the same trend as was shown by the original correlations; namely, the general factor accounts for an increasing amount of the variance between 9 and 12 years of age and for a decreasing amount between 12 and 15 years.

TABLE 15[4]

FACTOR ANALYSIS OF ALL VARIABLES—FIRST FACTOR LOADING

Tests	*Boys*			*Girls*		
	9	*12*	*15*	*9*	*12*	*15*
1 Vocabulary	.78	.72	.73	.74	.80	.67
2 Analogies	.76	.81	.78	.87	.87	.79
3 Sentence Completion	.84	.78	.73	.76	.87	.74
4 Number Series	.45	.70	.72	.75	.75	.75
5 Computation	.54	.67	.59	.64	.75	.57
6 Word-Word	.45	.46	.54	.50	.37	.48
7 Digit Span	.51	.53	.53	.60	.68	.44
8 Paper Form Board	.49	.63	.39	.62	.58	.43
Percentage of variance	35%	42%	37%	45%	48%	36%
Boys and girls	....	....	....	*40%*	*45%*	*36%*

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[4] Factor analysis of all the variables computed in the psychometric laboratory at Columbia University.

SECTION IV. DISCUSSION AND INTERPRETATION OF RESULTS

From the presentation of the results it is apparent that we are faced with the necessity of finding an explanation for the fact that the intercorrelations of our tests, instead of showing a continuous drop from 9 to 15 years, as would be expected in accordance with the theory that maturation or training produces an emergence of group factors coincident with a decreasing importance of the general intelligence factor, are higher at 12 years than at either 9 or 15 years of age (see Fig. 1). The decrease in the intercorrelations between 12 and 15 years can be adequately explained on the basis of a decrease in a general factor, thus confirming our hypothesis in regard to these two age groups. On the other hand, it is evident that a modification of the original hypothesis is required, in order to explain the rise in correlation from the ninth to the twelfth year of age. In the discussion of the literature pertaining to mental organization studies by Furfey, Bonham, and Sargent (8), Furfey and Muehlenbein (9), and Bayley (4) were cited, which indicated an almost complete lack of correlation between different abilities in infants. In evaluating such a result, one should not lose sight of the difficulties involved in testing infants, and also the fact that many abilities, such as verbal and numerical ability, do not make their appearance until later, so that they cannot be measured at all during infancy. Hence, one must be extremely cautious in drawing any conclusions as to the nature of mental organization in very young children. If we assume, on the basis of the rather meager evidence at present available, that the degree of mental integration is quite low in infancy, a considerable rise in the correlation between the various abilities must occur at some stage in the child's growth. In fact, the hypothesis of Asch (3) foresaw such a possibility, even though his own study of mental growth did not shed any light on the matter. His results appeared to indicate that this process of integration must be completed some time before the twelfth year, since he found a decrease in the correlations between 9 and 12 years of age. Our results disagree with those of Asch, inasmuch as they showed a rise in correlation between these age levels. The explanation of the discrepancy may lie in the restricted age range of one year for each group employed in the present study, as contrasted with an age range of five years for Asch's groups. Such a wide age range would favor the introduction of a maturation factor, which would tend to raise the correlations. Because growth is more rapid at 9 years of age than at 12, this factor would have more effect on the younger group and, hence, might account for the high correlations found in this group.

The earlier study of Garrett, Bryan and Perl (12) also showed a drop in correlation between 9 and 12 years of age. Unlike Asch, they employed a restricted age range, so that in their study the influence of maturation was kept at a minimum. As regards the explanation of the discrepancy between our results and those of Garrett, Bryan and Perl, it may lie in the different makeup of the two test batteries. The battery of ten tests employed by Garrett, Bryan and Perl, consisted of six memory tests and only four non-memory tests, whereas the present battery of eight tests contained six non-memory tests and only two memory tests; *i.e.*, their battery consisted predominantly of memory tests, ours of non-memory tests. Four of their tests, Vocabulary, Word-Word, Digit Span, and Paper Form Board, are identical with ours. Table 16 shows the comparison of the two sets of results using only these four tests. In both cases the correlations for the boys are highest at the 12-year level. In our results the rise from 9 to 12 years is smaller than the drop from 12

TABLE 16

COMPARISON OF PRESENT R'S WITH THOSE OF GARRETT, BRYAN AND PERL
(Upper rows—present results. Lower rows—G., B. & P. results)

	Boys			*Girls*		
	9	*12*	*15*	*9*	*12*	*15*
Intragroup r's						
Memory	.131	.191	.165	.360	.101	.146
	.177	.082	.028	.288	.132	.094
Intergroup r's						
Vocabulary with	.385	.214	.460	.282	.273	.156
Word-Word	.211	.185	.280	.237	.247	.212
Vocabulary with	.423	.512	.390	.361	.522	.222
Digit Span	.078	.284	.277	.339	.156	.212
Vocabulary with	.248	.379	.138	.405	.391	.265
Paper Form Board	.013	.404	.119	.239	.456	.296
Word-Word with	.031	.273	.185	.413	.155	.197
Paper Form Board	−.115	.286	−.095	.214	.192	.029
Digit Span with	.344	.251	.123	.288	.461	.169
Paper Form Board	.061	.131	−.023	.310	.315	.068
Average r's						
All tests	.297	.322	.277	.355	.353	.197
	.128	.253	.173	.275	.273	.179

to 15, whereas the reverse is true for the Garrett, Bryan and Perl results. The results of the two studies are identical for the girls, who fail to show a significant drop in r from 9 to 12 years, but showed a marked decrease from 12 to 15. Hence we may conclude that the difference between our total results and the total results of Garrett, Bryan, and Perl is due to the differences in the construction of the two test batteries, since their battery consisted predominantly of memory tests, which show lower reliabilities than the non-memory tests, and which correlate less with each other than do the latter. When we compare only the results on identical tests, the findings in the two studies show substantial agreement.

However, another possible explanation of the discrepancy between the present findings and those of previous workers may lie in the pains taken to eliminate the verbal factor from the tests of number ability in this study. All the previous investigators utilized arithmetic problems as one of the tests—frequently the only one—of number ability. Now, it is likely that arithmetic problems involve considerable verbal comprehension for 9-year-old children, since Thurstone (26) has shown that they contain a verbal factor even at the senior high school level. The verbal comprehension factor, because of its close relation to reading skills, is probably of prime importance for the test performance of young children, but less so at the older age levels. Hence, the selection of tests in which there is an overlapping of this factor would tend to boost the correlations between such tests, more especially in the younger age groups. On the other hand, the rather meager evidence at present available, indicates that spatial-performance tests split away sharply from the verbal and number tests even in the youngest children (16).

Our data then indicate that our original hypothesis was only partially correct, and that it should be modified to include the rise in correlation from infancy to childhood postulated by Asch (3). The hypothesis may then be re-stated as follows: beginning with a minimum of integration at birth, there is a gradual increase in integration of mental ability, which reaches a maximum at approximately 12 years of age; after which there is a decrease in relationship due to the crystallizing out of group factors. Evidently Asch assumed the process of integration to be complete at a much earlier age than is indicated by our results. He regarded the development of symbolic speech as of prime importance in this process. However, the fact that the correlations tend to be higher at the twelfth year, suggests that factors other than speech may play a more significant role.

It is our opinion that non-intellectual influences, such as the instability of attention and interest characteristic of young children may be responsible for the lowering of the correlations at the 9-year level. In fact, their effect on test performance may be so important as largely to overshadow any relationship that may exist amongst intellectual abilities at the early age levels. Much of the work in school is aimed indirectly at increasing both the duration and the span of attention, and by the time a child has reached 12 years of age his training in this respect is fairly near completion. The same is not true of 9-year-old children who have had less than four years, and in some cases, less than three years of training in concentration on set tasks. If we incorporate this aspect of development into our theory of mental growth, we may describe the maturation of the mental processes as follows: the stabilization of attention and interest increases from early infancy up to the age of 12 years approximately, and manifests itself in an increase in the correlation between tests of various mental abilities; beyond this age the crystallizing out of various group factors in intelligence again causes the intercorrelations to decrease. It is possible that the crystallization process begins before 12 years, but if so, it is obscured by non-intellectual influences and, only when the effect of these has been stabilized with increasing maturity, does it become apparent.

The second part of our theory of mental development posited an increase in the intragroup correlations of the tests with increase in age to correspond with the emergence of group factors in intelligence. An examination of Table 14 shows that there is no clear-cut trend of this kind. The intragroup r's for the girls follow the same direction as the intergroup r's and, although the average of all the intragroup r's for boys does show a consistent increase over the three age levels, there is considerable variation among the trends for the individual group factors. The explanation for this discrepancy with theory most probably lies in the great difficulty, almost impossibility, of constructing tests which are pure measures of only one group factor and which are not contaminated by large amounts of one or more other factors. The highest projection of any factor loading found by Thurstone (25) in his attempts to construct tests of group factors was .812 for Multiplication in the group of tests for number ability. Most of the projections fell between .40 and .50. The Thorndike Vocabulary Test, a modification of which was used by us, was found by Thurstone to have practically equal loadings of two separate verbal factors, V and W, together with an equally heavy loading of a third factor P, or perception. Number Series, another of our tests, was shown to be largely loaded with factor I, or induction. In regard to memory tests, there are a number of indications that memory is not a unitary ability, but may consist of several different abilities. Anastasi (2) in her second research on memory, in which she tested very different types of memory, failed to find a general factor running through her tests. In her earlier paper (1) she had already noted that digit span split off from the other tests of rote memory. She wrote: ". . . it seems probable that digit span is not primarily a test of memory for an adult group of subjects, performance on it probably depending on incidental factors, such as attention, an active attitude, desire to do well on this test, etc." Thurstone (27) also noted low correlations between digit span and other tests of rote memory, and he felt that it might be due to the presence of a serial factor in the former. He planned to investigate further the relationships of various types of memory material. Clinical experience borne out by statistical results shows that the scores on tests of rote memory, especially digit span, are so highly influenced by non-intellectual factors, particularly anxiety, as to show relatively little relationship with intellectual ability. In fact, when a group of normal control subjects was subdivided into two groups of anxious and non-anxious subjects, the former obtained significantly lower scores on the digit span test.[1] Our other memory test, Word-Word, had the lowest reliability of any of the tests employed in this study. This was probably due to the shortness of the test and resulting low scores. From the above discussion it is apparent that none of our tests, with the possible exception of Computation, can be regarded as adequate tests of any single group factor; hence, the distinction made between inter- and intragroup tests is largely arbitrary. Most of the tests involved several group factors and there was considerable overlap between the different types of tests. Furthermore, it has been shown that the loadings of the various factors may change with age (26), with ease or difficulty of the tasks (14), and even with test structure (18). Hence, it is not surprising that our results failed to show a consistent increase in the intragroup correlations with increase in age.

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[1] Results to be published in a forthcoming monograph on clinical psychological testing by Rapaport, D., Gill, M., and Schafer, R.

SECTION V. SUMMARY AND CONCLUSIONS

1. The purpose of the study was to investigate the hypothesis that intelligence is relatively generalized in young children, but that as age increases there is a gradually increasing specialization of mental abilities, which should result in a decrease in the correlations between tests of different group factors and an increase in the correlations between tests of the same group factor.

2. In order to test this hypothesis a battery of eight tests, consisting of three tests of verbal ability, two tests of number ability, two tests of memory, and one test of spatial relationships, was administered to children of three different age levels, 9, 12, and 15 years. Correlations between the tests at each age level were computed for boys and girls separately.

3. The average correlations showed an increase from 9 to 12 years and a decrease from 12 to 15 years. The boys showed a sharper increase than the girls, and the girls showed a sharper decrease than the boys.

4. In conformity with the data the original hypothesis was amended as follows: beginning with a minimum of integration at birth, there is a gradual increase in integration of mental ability, which reaches a maximum at approximately 12 years of age; after which there is a decrease in relationship due to the crystallizing out of group factors. It was suggested that the increasing integration is related to an increase in the stability of attitudinal influences, such as attention and interest.

5. The failure to obtain increases in the intragroup correlations with increasing age was attributed to the difficulty of obtaining tests of pure group factors, inasmuch as all the tests included varying amounts of other factors in addition to the one to be tested. Furthermore, the abilities employed in the performance of any task have been shown to vary with age, with the difficulty of the task, and even with the structure of the test. All these factors tend to complicate the study of the relationships among primary abilities in mental organization.

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APPENDIX 1

Average r's Corrected for Attenuation

	Boys			Girls		
	9	*12*	*15*	*9*	*12*	*15*
Intragroup r's						
Verbal	.73	.72	.80	.77	.83	.76
Number	.33	.61	.68	.53	.72	.55
Memory	.19	.25	.23	.49	.13	.21
Intergroup r's						
Verbal—Number	.91	.83	.63	.90	.82	.82
Verbal—Memory	1.0	1.0	.61	.86	1.0	.91
Verbal—Spatial	.56	.53	.32	.42	.60	.26
Number—Memory	.95	.91	.91	.86	1.0	1.0
Number—Spatial	.48	.62	.42	.73	.61	.45
Memory—Spatial	.58	.63	.38	.63	1.0	.49

APPENDIX 2

r's for Boys 9 and 12 Years Old, Fourth and Seventh Grades Only

Tests	*9*	*12*
Vocabulary—Number Series	.289	.277
Vocabulary—Word-Word	.190	.225
Vocabulary—Paper Form Board	.280	.288
Number Series—Paper Form Board	.301	.512
Word-Word—Paper Form Board	−.022	.133

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